Meal Replacement Mass Reduction and Integration Acceptability Study

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Study Overview

- JSC Food Lab is responsible for providing food for manned space exploration

  -Currently provide food for ISS

  -AFT is developing foods for Orion and Mars exploration

- ISS food system has over 150 menu items

- Orion vehicle is mass and volume constrained with no resupply

  -Must achieve a 10% mass reduction across the food system

  -High-calorie meal replacement bars are the best option

Study Aims

- Develop calorically dense meal replacement bars that achieve a 10% mass reduction
- Assess bar stability over 5 years
- Determine an acceptable implementation schedule using the Human Exploration Research Analog (HERA)

Bar Requirements

- Target caloric density of 4.5 kcal/g (700 kcal per bar)
- Target 35% fat (Not to exceed 7% saturated fat)
- Water activity of 0.6 or below

Average Bar Nutrition

- Macronutrients

On average, bars contain about 22.8 g protein, 88.5 g carbohydrate, 29.5 g fat

- Vitamins

Bars were low in folic acid, thiamin, vitamin B12, vitamin C, vitamin K1, calcium, and potassium (Banana Nut Bar was fortified with a vitamin premix)

- Minerals

Sodium content of overall food system decreased by ~200 mg per day with meal bars

Nutritional Comparisons

	ISS Standard Menu	Meal Replacement Menu
Calories (kcal)	2199	**2310**
Carbohydrates (g)	297	294
Protein (g)	116	120
Saturated Fat (g)	27	24
Fat (g)	71	**81**
Fiber (g)	29	31
Calcium	819	**721**
Potassium (mg)	3485	3578
Sodium (mg)	2722	2496
Macronutrient Profile	52% Carbs	50% Carbs
	20% Protein	20% Protein
	28% Fat	**30% Fat**

Bar Variety

	Savory	Sweet	Chocolate	Fruity	Cake Bar	Nut Bar
Banana Nut		X			X	
Chocolate Peanut Butter			X		X	
Cinnamon Roll		X			X	
Ginger Vanilla		X			X	
Hickory Smoked BBQ	X					X
Jalapeno Nut	X					X
Maple Bacon	X	X				X
Orange Cranberry				X	X	

Carver Press

Ultrasonic Press

Ginger Vanilla Bar
701.6 kcal per serving
4.3 kcal/g

Banana Nut Bar
702.4 kcal per serving
4.08 kcal/g

Orange Cranberry Bar
704.4 kcal per serving
4.1 kcal/g

Cinnamon Roll Bar
701.1 kcal per serving
4.0 kcal/g

Jalapeño Nut Bar
700.9 kcal per serving
3.8 kcal/g

BBQ Nut Bar
702.5 kcal per serving
3.9 kcal/g

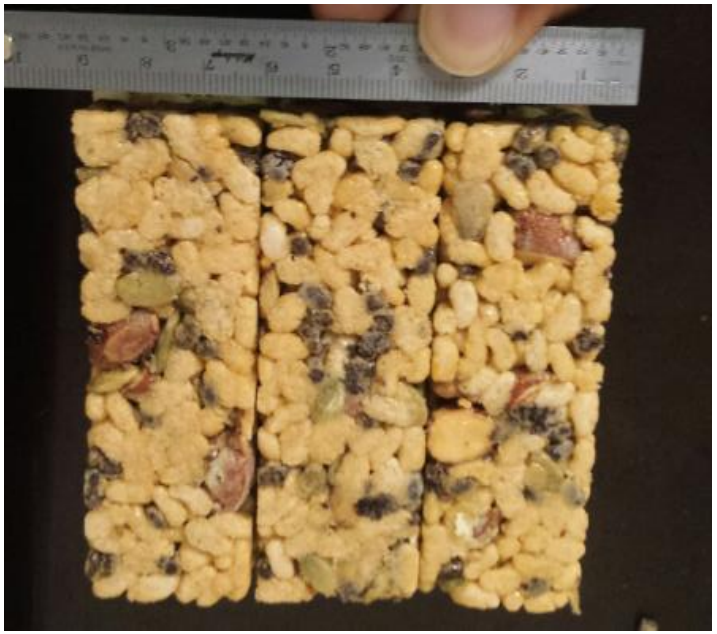
Maple Bacon Nut Bar
700.7 kcal per serving
3.8 kcal/g

Peanut Butter Chocolate Bar*
711.2 kcal per serving
4.4 kcal/g

Banana Nut – Carver Press

Banana Nut – Ultrasonic Press

Carver Press – Nut Bar



Ultrasonic Press- Nut Bar

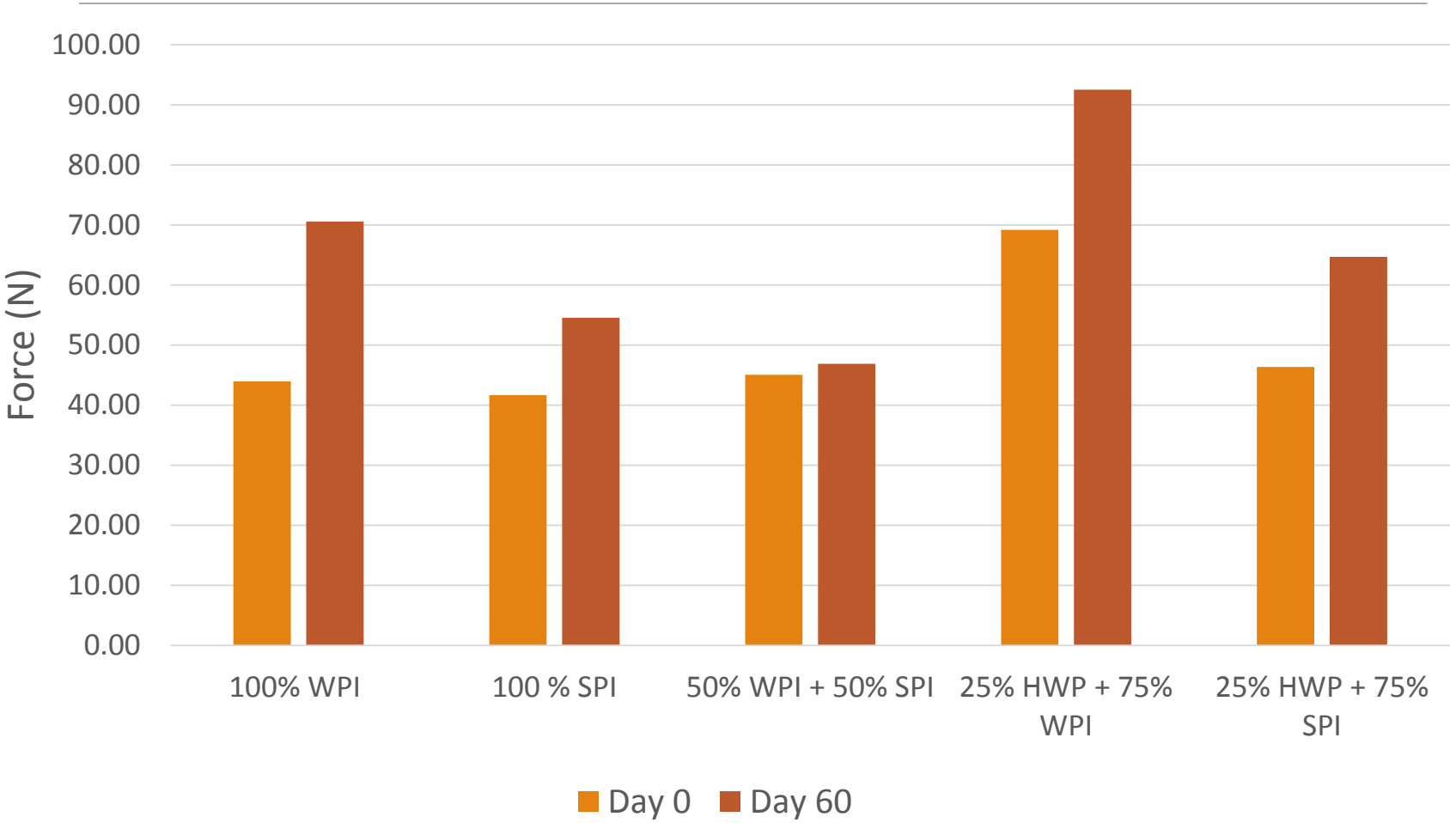
Initial Sensory Acceptability Scores

	Overall	Appearance	Color	Aroma	Flavor	Texture
Banana Nut (UC)	7.45	7.33	7.36	7.45	7.36	7.36
Orange Cranberry (UC)	7.33	7.67	7.52	7.15	7.36	7.67
Ginger Vanilla (TC)	7.23	7.17	7.31	6.97	7.17	7.43
Jalapeno Nut (TC)	7.11	7.08	7.00	6.56	7.25	6.92
Banana Nut (TC)	6.91	6.23	6.83	7.11	7.03	5.86
Honey BBQ Nut (TC)	6.50	7.14	7.00	6.44	6.25	7.19

Bar Optimization

- Texture and Hardness
- Oil Binding

Effects of Protein Type on Bar Hardening



Storage at 35˚C

Oil Loss

HWP + SPI

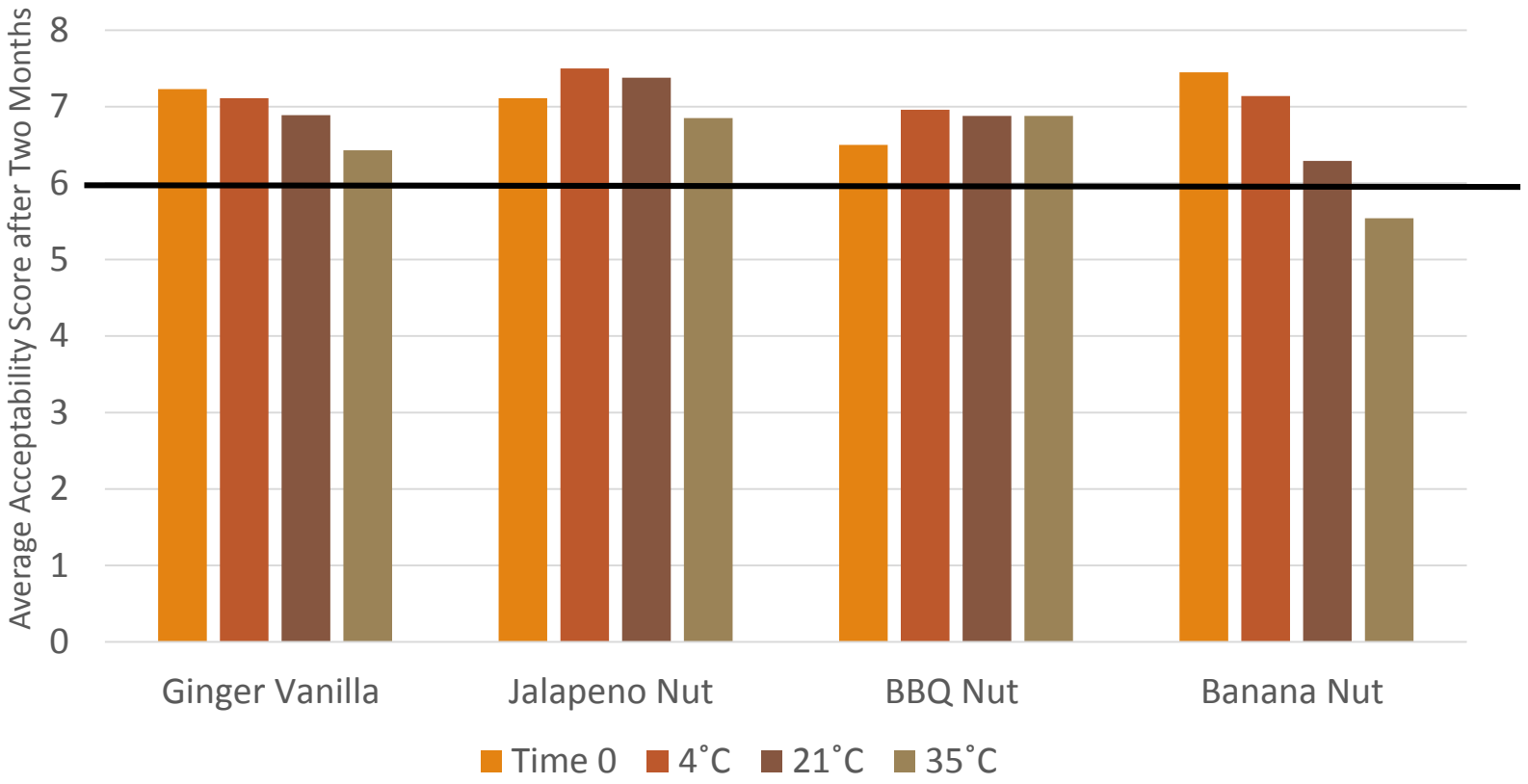
100%SPI

Bar	Protein Type
Jalapeno Nut Bar	Whey protein powder and Soy protein nugget
Banana Nut Bar	Vanilla whey protein concentrate
BBQ Nut Bar	Whey protein powder and soy protein nugget
Orange Cranberry Bar	Whey Protein Powder (Industrial)
Ginger Vanilla Bar	Soy Protein Powder

Shelf- life Study

- Sensory Acceptability
- Texture
- Color

Sensory Acceptability Over Time



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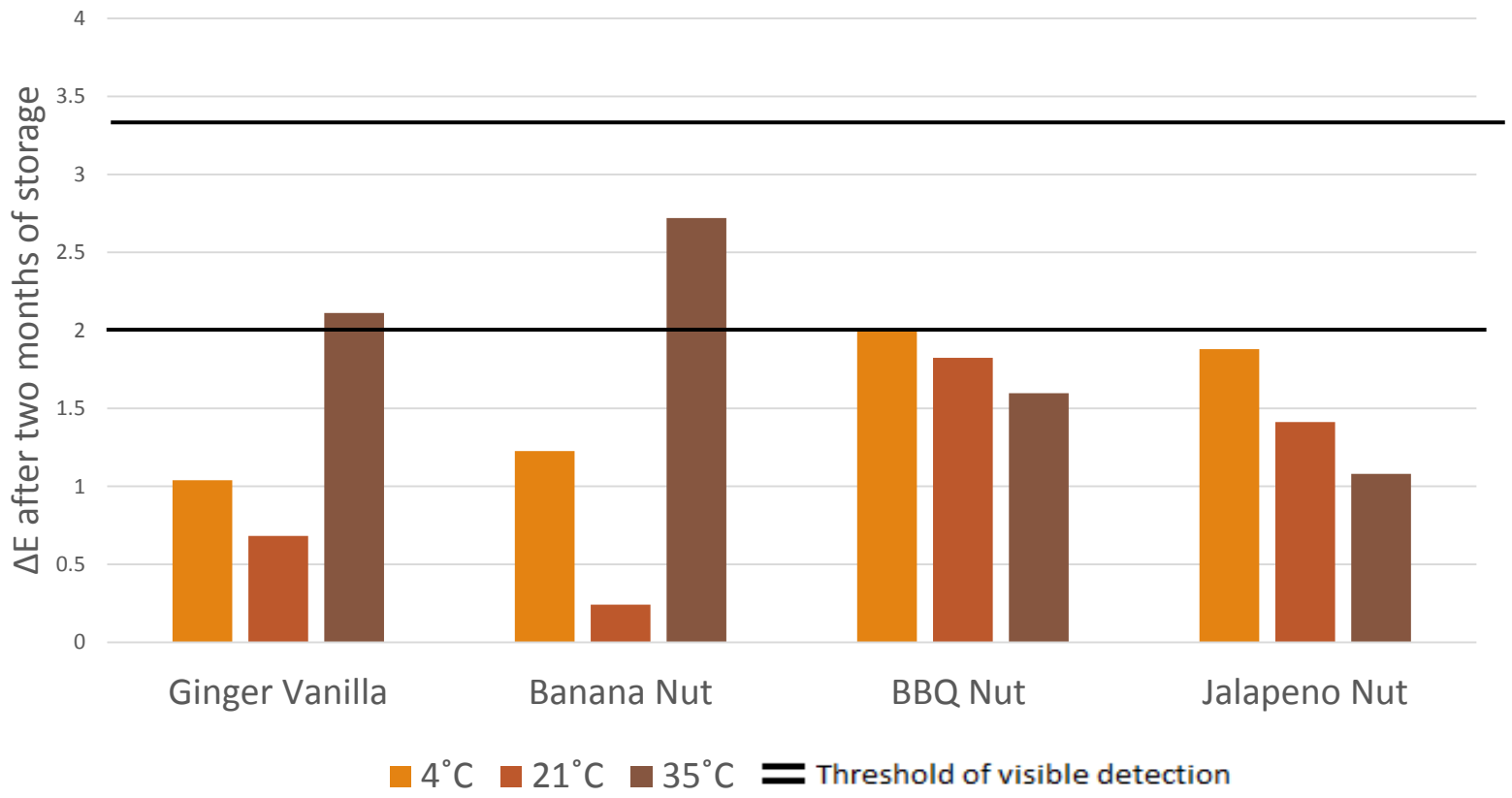
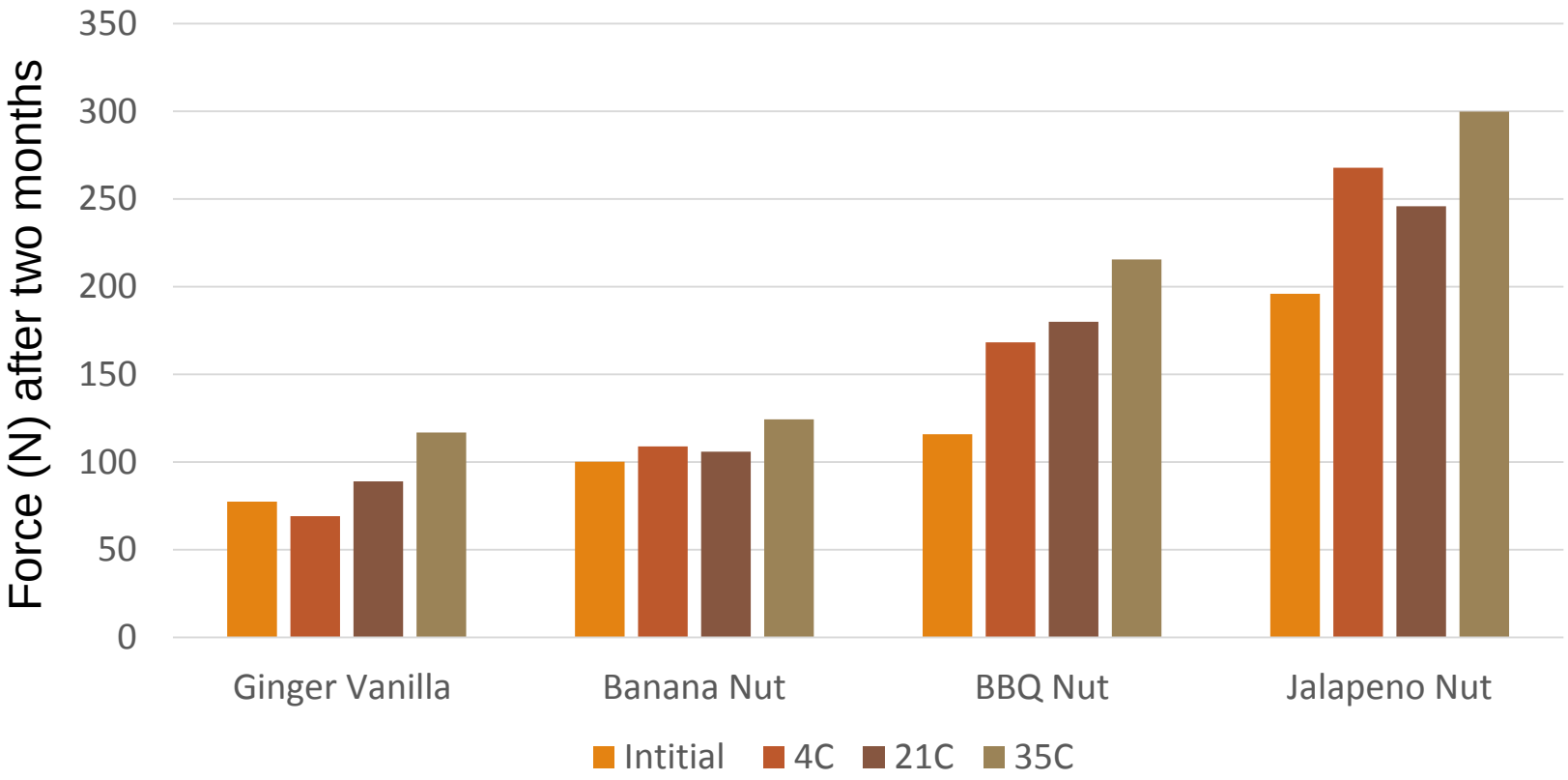
Color Change over Time



Texture Change Over Time



Key Findings

- Ultrasonic bars are slightly more favorable than traditional bars, however rancidity is more apparent at higher temperatures

- Average caloric density is 4.1 kcal/g and ~700 kcal per serving

- Fortification is required to satisfy vitamin requirements

Ongoing Work

- Shelf-life study to determine long-term stability of formulated bars
- Determination of meal replacement frequency in HERA

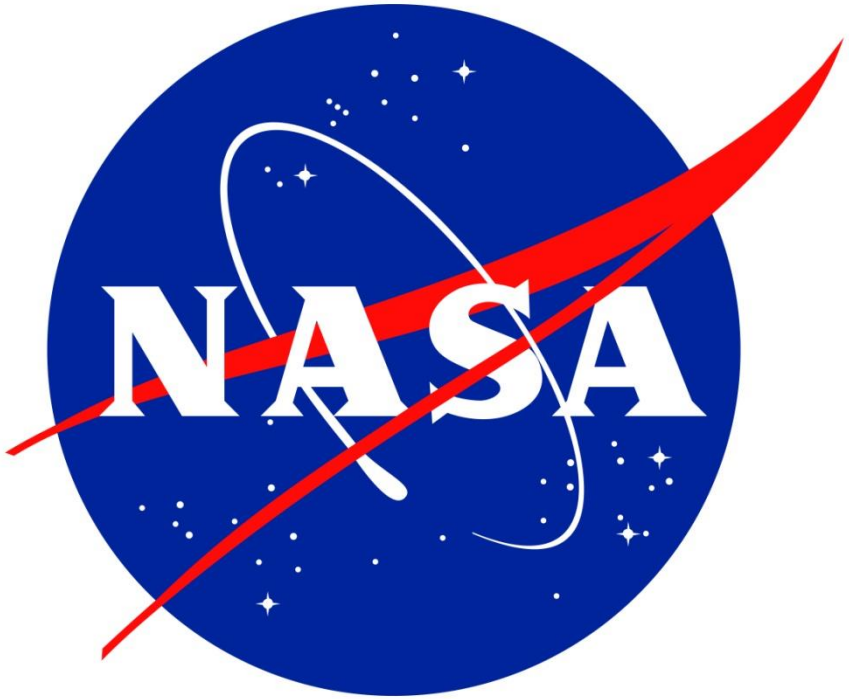
HERA

- 4 crew members
- 30 days
- 4 missions

Acknowledgments

- Dr. Anne Barrett, Dr. Tom Yang and Dr. Michelle Richardson (NATICK) for assistance with bar production

- Roberto Capodieci for assistance with production of ultrasonic bars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